

Experimental Investigation on the effect of water ingress on the flexural and interlaminar properties of glass/vinyl-ester composite for marine applications

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FIBRESHIP3
INTEGRAL COMPOSITE SHIP

Bernal
Institute

Marine Aging of Polymers, Brest
28-29 August 2019



Contents



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➤ Conclusions

➤ Acknowledgements



Ship Block Demonstrator
(iXblue Shipyard, La Ciotat, France)

Overview

- Composites dominate construction of small-to-medium length vessels (< 50 m)
- Restriction on use of composites on ships longer than 50 m !
- Main Reason: Lack of design guidelines from certification bodies

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- Main issues: Safety - particularly **Fire**
- The trend in aviation (e.g. B787, A350) demonstrates that adoption of composite technology in primary and secondary structures is feasible



Courtesy of Tuco Marine (FIBRESHIP partner) – ProZero range of offshore/patrol/service FRP vessels (8-18 m)



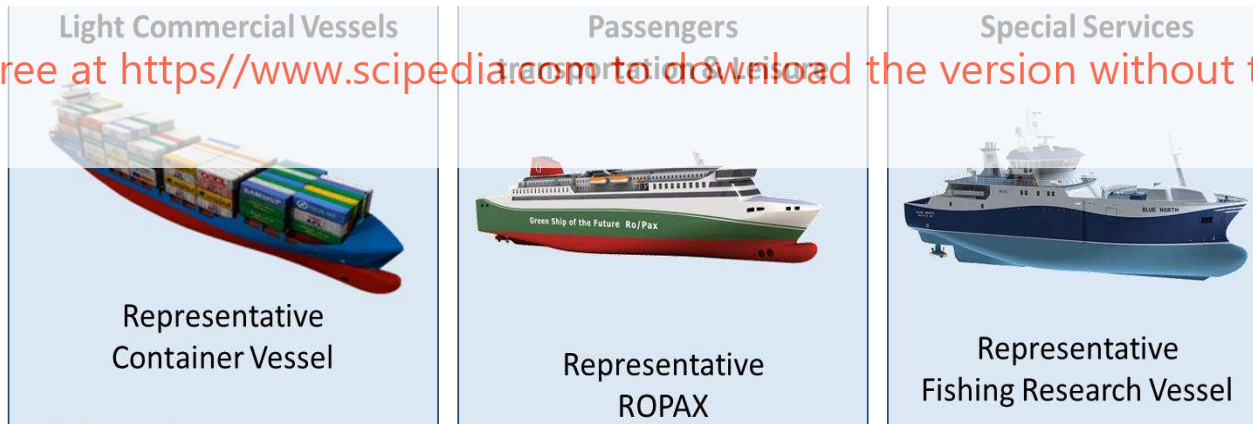
PROMARINE, OUEST composites SEMI RIGID Boat (JEC 2019)

Challenge

- Enhance acceptance of composites in primary structures of ships > 50 m
- Recommend relevant changes in rules and regulations to the responsible bodies
- Create a niche market opportunity for the manufacture of large marine vessels in the EU

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Engineering, production and life-cycle management for the complete construction of large-length FIBRE-based SHIPs

Partners

- 18 partners, 11 countries

- European shipyards: 3

- Naval architect/design/engineering companies: 4

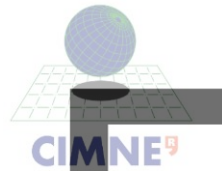
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- Ship owners & operators: 4

- R&D organisations: 4

- Classification/certification bodies: 3

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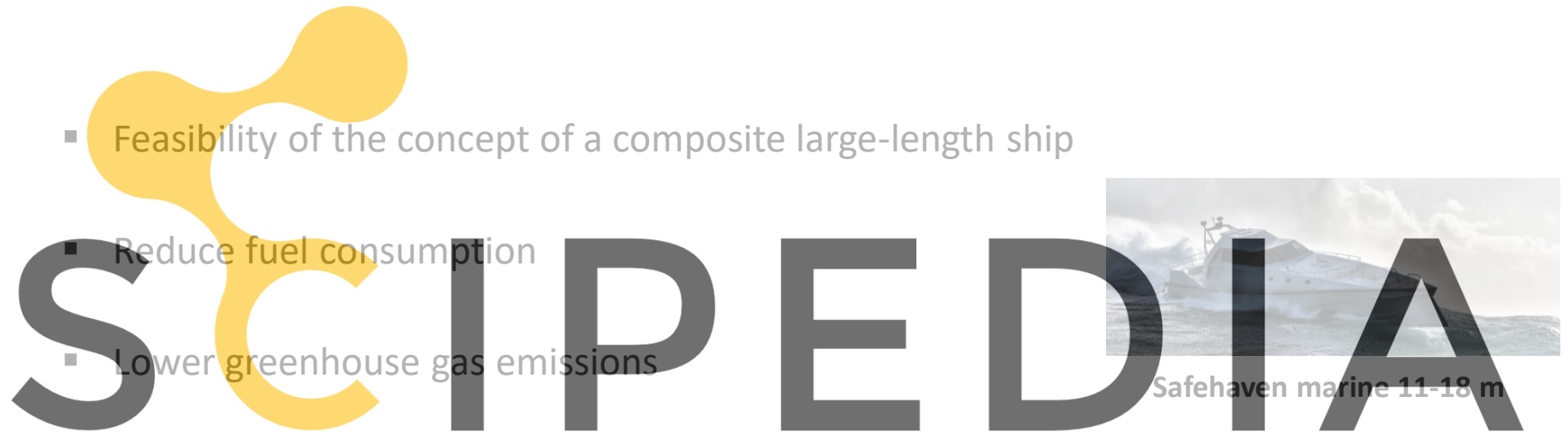
FOINIKAS SHIPPING
COMPANY



NAVROM
SHIPYARD



Technical Impact



- Feasibility of the concept of a composite large-length ship

- Reduce fuel consumption

- Lower greenhouse gas emissions

- Increase of payload cargo capacity

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- Underwater noise reduction

- Reduce maintenance and life cycle costs

- Corrosion-free



Safehaven marine 11-18 m



Swedish Navy Visby > 70 m

Context

Ships are exposed to under a wide range of environmental conditions



Durability of composites may be compromised

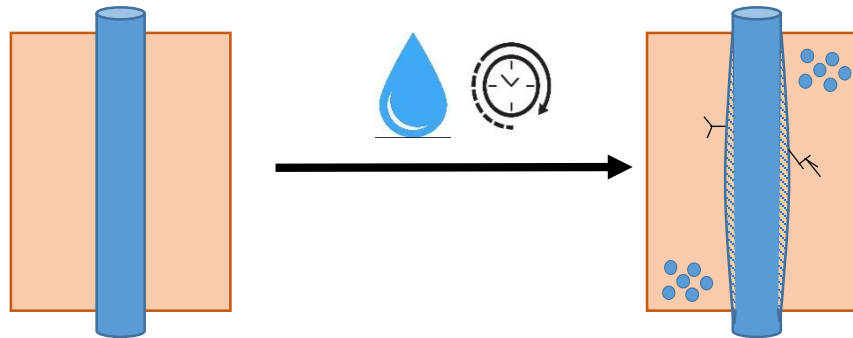


Service life of marine composites (typically 20-25 years)



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The mechanical and thermal properties degrade accordingly, and the service life is shortened



Background

- Recent publication in Composite Part B (Available online August 10)

<https://doi.org/10.1016/j.compositesb.2019.107271>

- Objective:** Evaluate and compare ILS, flexural properties and failure modes of four different material systems under short term immersion in water and diesel

- Current study focuses on one material system for a longer duration (3 mths)



Effect of environmental conditioning on the properties of thermosetting- and thermoplastic-matrix composite materials by resin infusion for marine applications

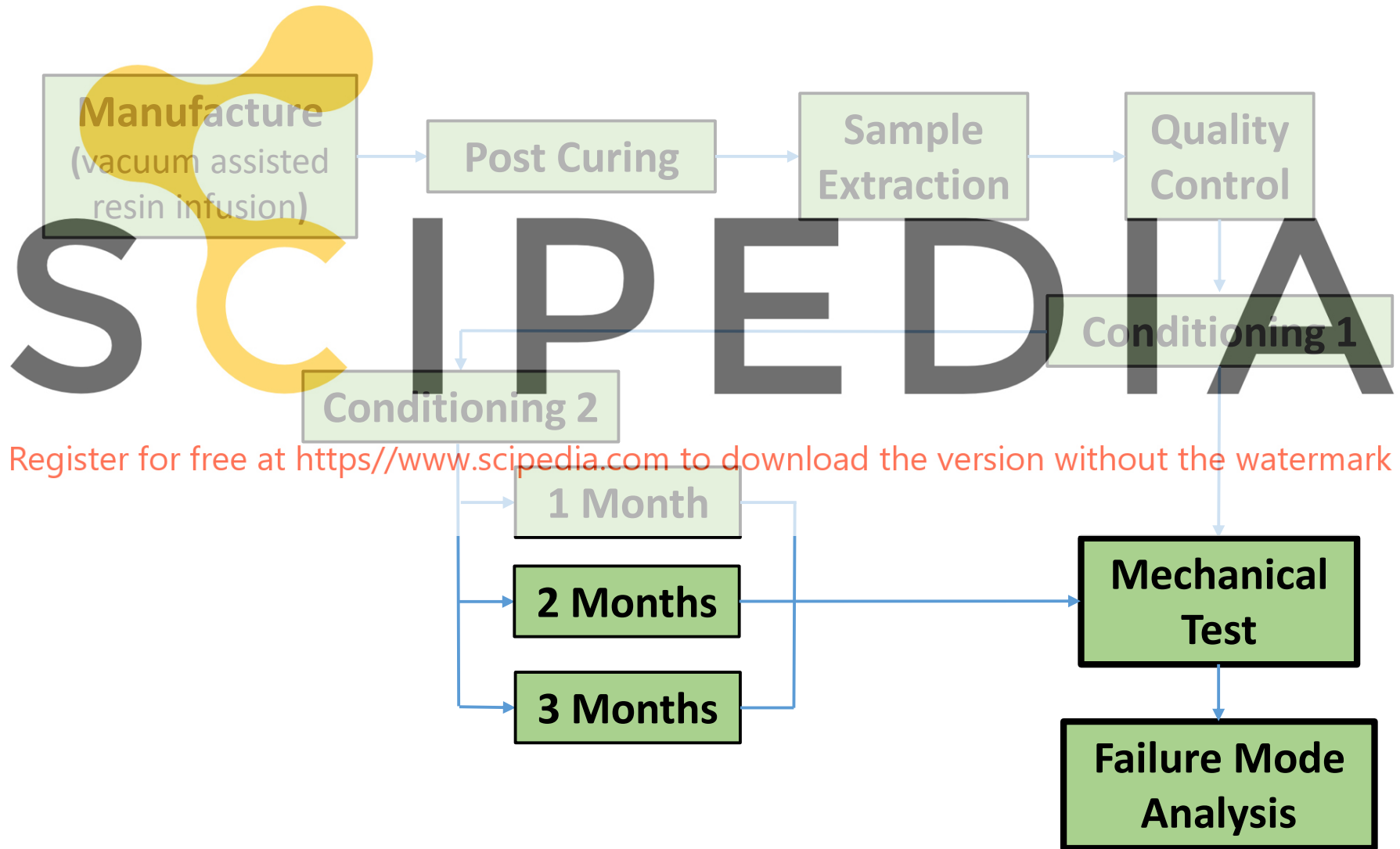
N.H. Nash^a, A. Portela^a, C. Bachiour^a, I. Manolakis^a, A.J. Comer^{a,b}

Objective

Evaluate the flexural, interlaminar shear properties and failure modes of a glass/vinyl-ester laminate under dry and wet conditions.

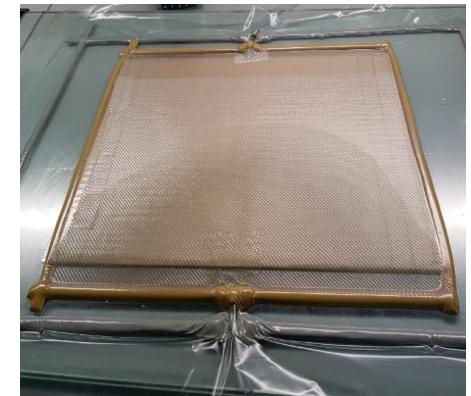
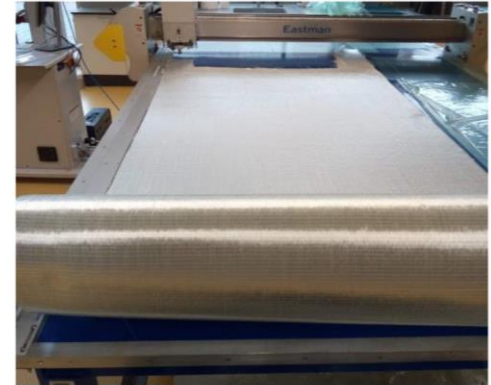
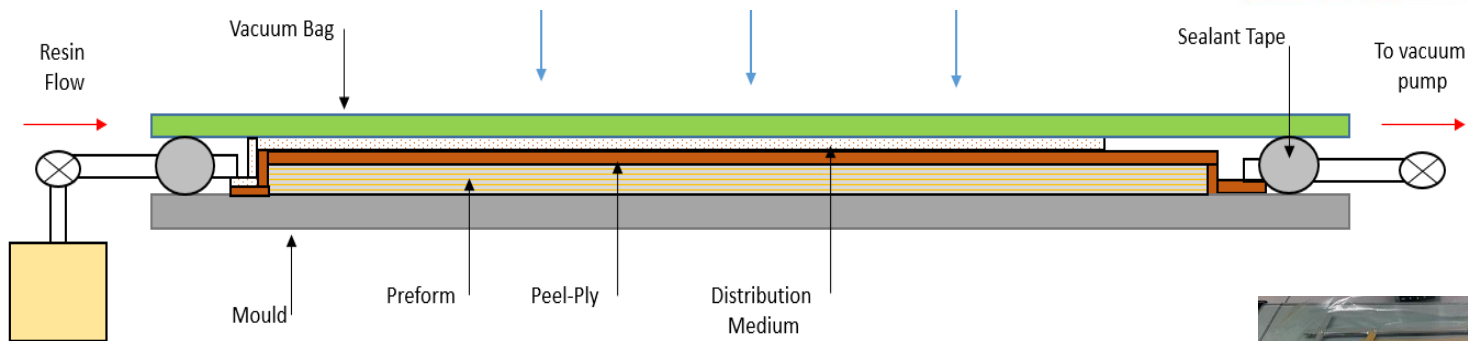
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Experimental Details



Experimental Details

Manufacturing of composite laminate



- Lay-up: O_{2S} (4 layers of NCF)
- SAERTEX U-E-940 g/m²-LEO UD
- LEO Injection Resin 8500 from BÜFA

Quality Control

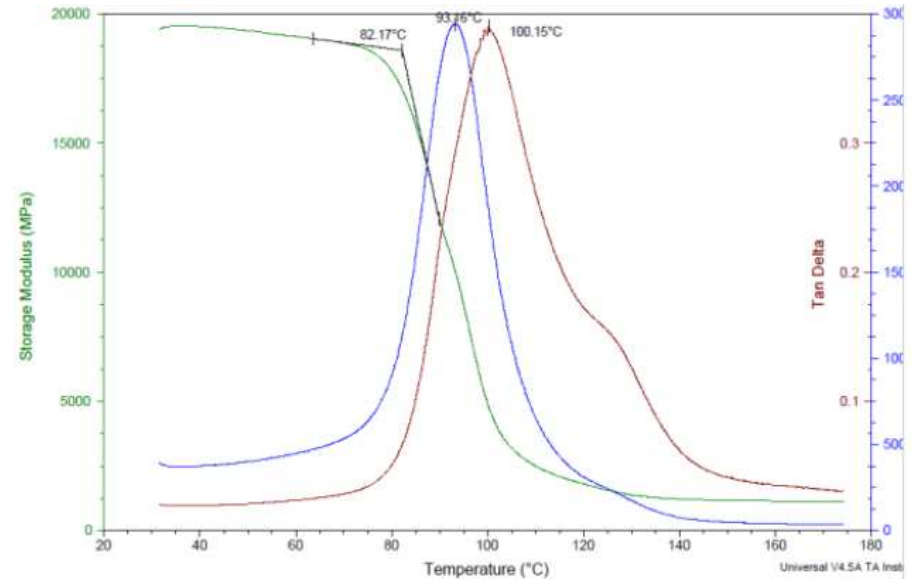
- Cured ply thickness

Laminate	Cured Ply Thickness
Range	0.64 ~ 0.66

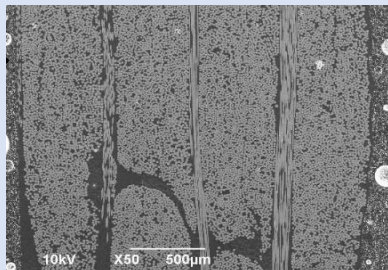
- Fibre Volume Fraction

Laminate	ISO 14127:2008	ASTM 3171
Fibre Volume %	55.3%	54.5%

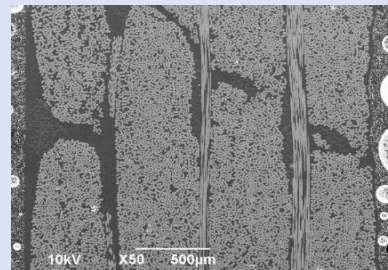
- T_g and degree of cure



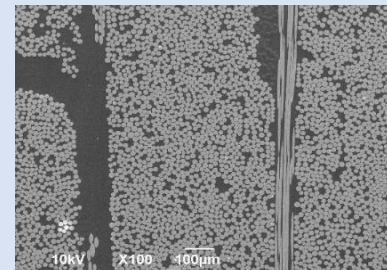
- Void Analysis (MS 0051)



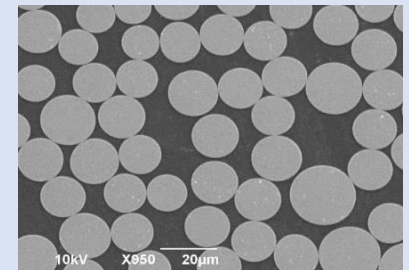
x50



x50



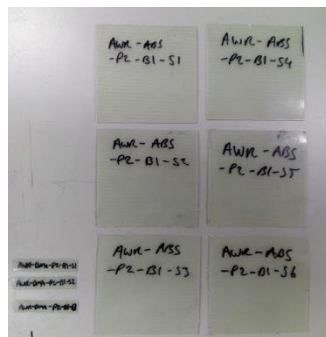
x100



x950

Conditioning 1 and 2

✓ Procedure 1



Oven for 5 hours at 45°C



Record the Mass

✓ Procedure 2



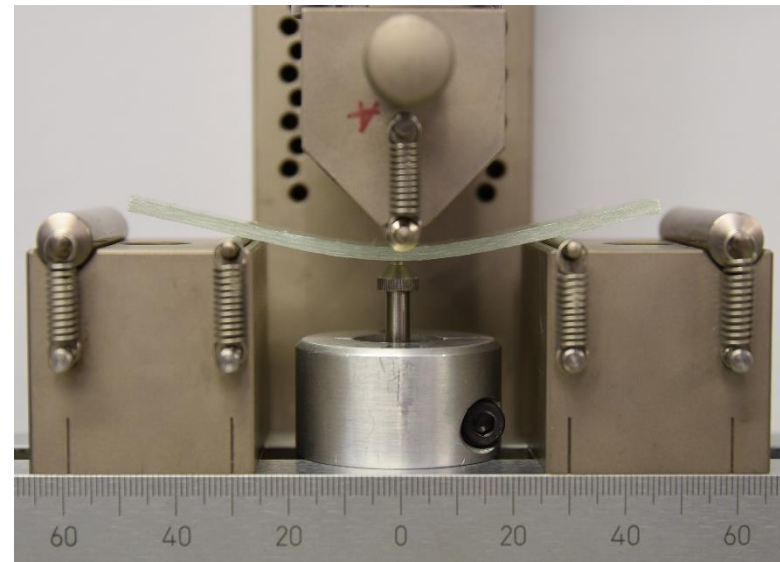
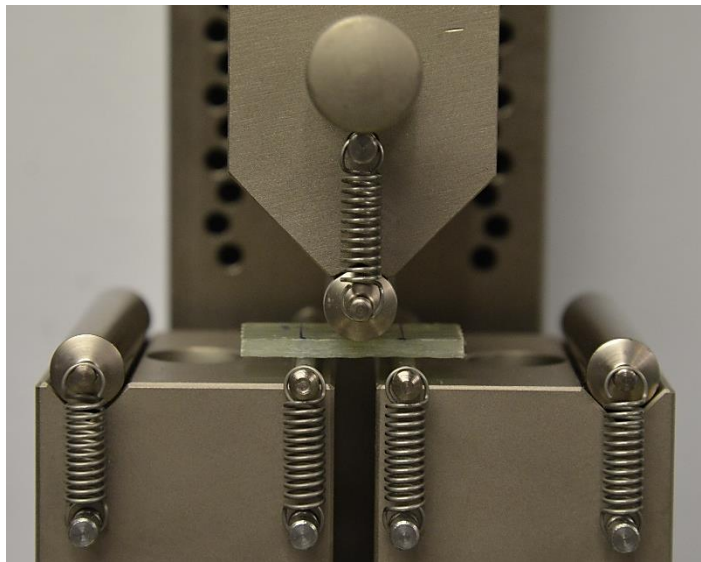
Immersion Bath (Deionised water @ 35 °C)



Record water uptake
(ASTM D5228)

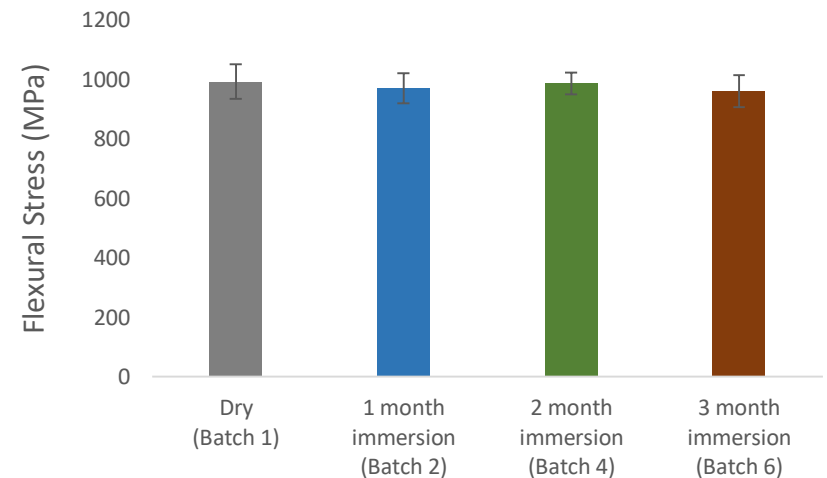
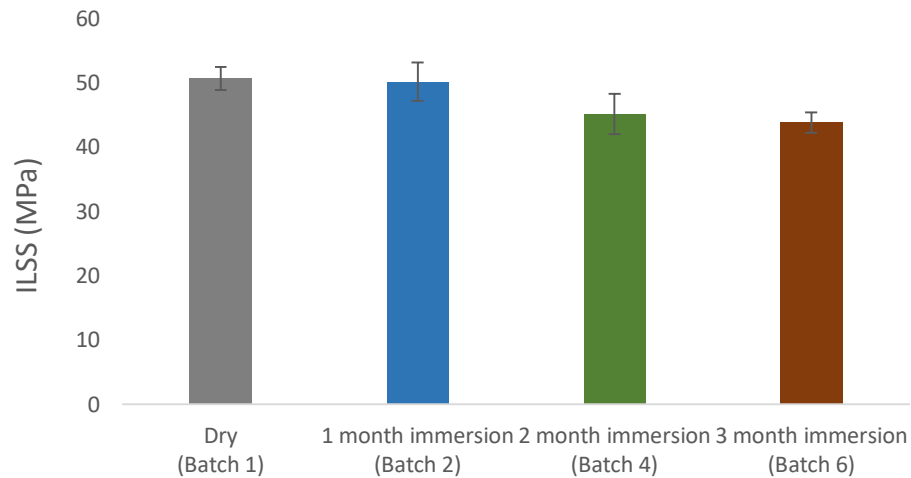
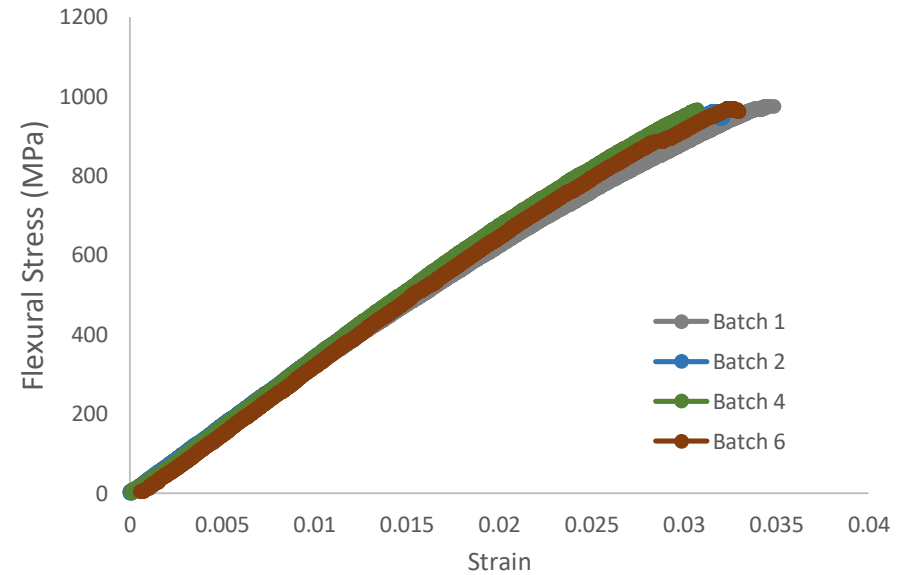
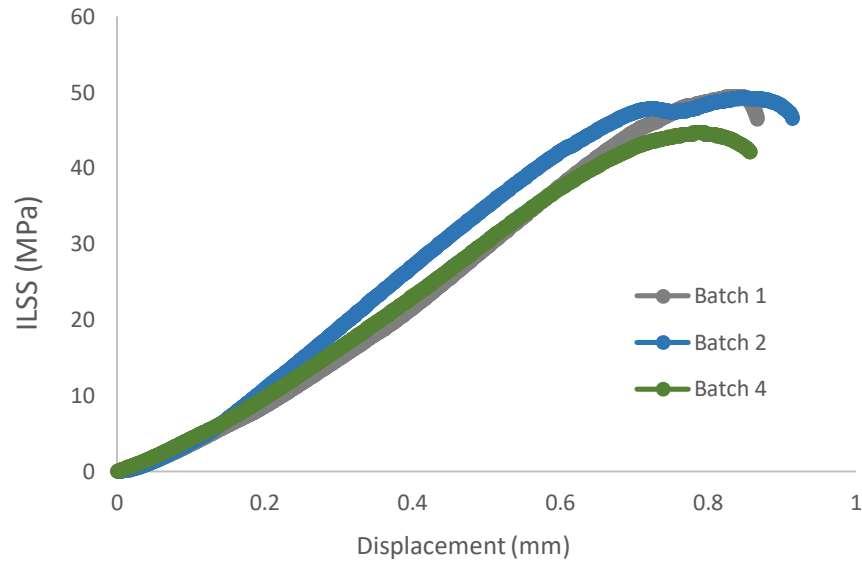
Experimental Details

Test	Standard	Properties	Nominal Sample Dimensions	Number of Samples
INTERLAMINAR SHEAR (ILS)	ISO 14130	APPARENT INTERLAMINAR SHEAR STRENGTH	30 mm X 15 mm X 3 mm	5 No immersion 5 after 1 mth immersion 5 after 2 mth immersion 5 after 3 mth immersion
FLEXURE – 3 POINT BEND	ISO 14125	FLEXURAL STRENGTH FLEXURAL MODULUS	100 mm X 15 mm X 3 mm	



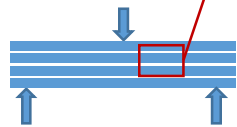
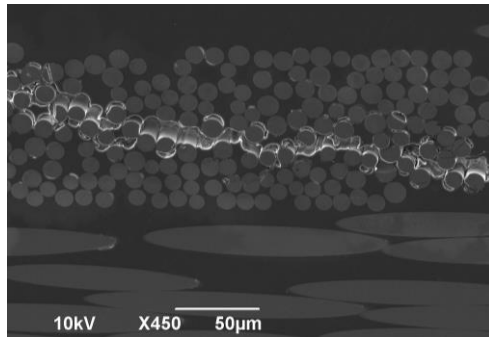
30:1

Results



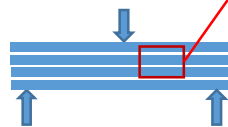
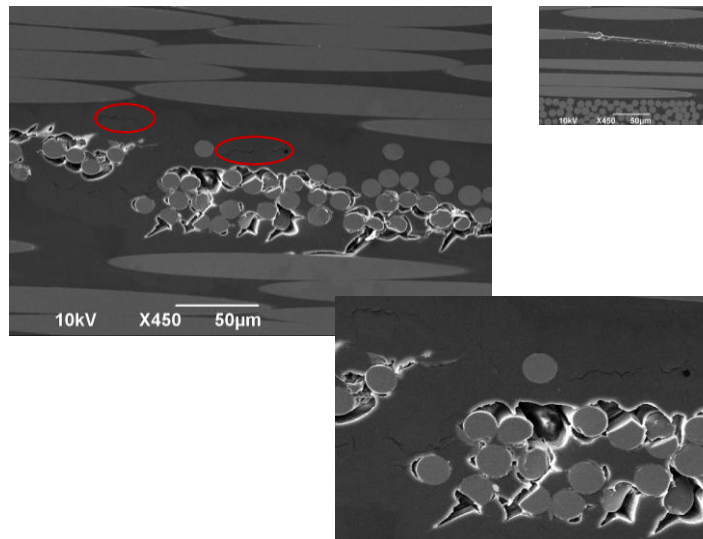
Failure Mode: ILS

**1 mth immersion
(98% retention)**



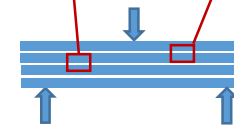
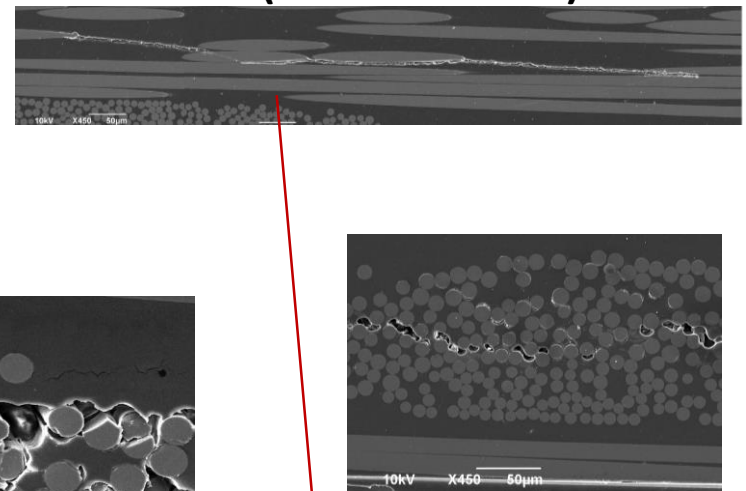
Shear crack formation at fibre-matrix interface in 90° tows

**2 mths immersion
(89 % retention)**



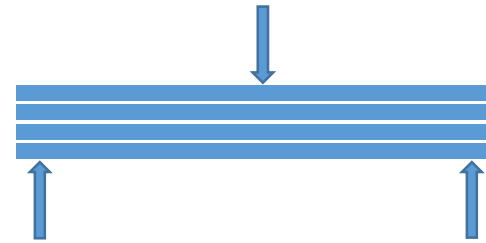
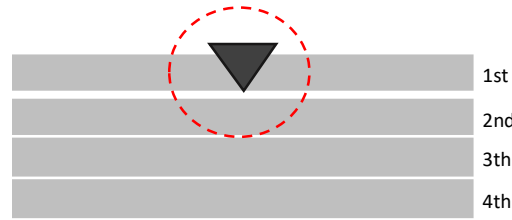
Micro-crack formation in the matrix plus shear crack formation at fibre-matrix interface in 90° tows

**3 mths immersion
(86 % retention)**

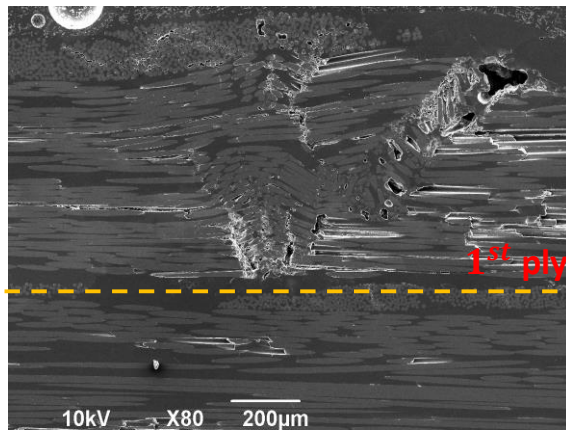


Crack formation at 0° fibre-matrix interface plus shear crack formation at fibre-matrix interface in 90° tows

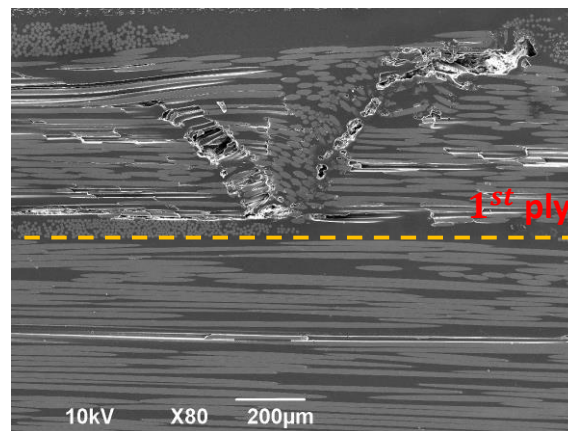
Failure Mode: Flexure



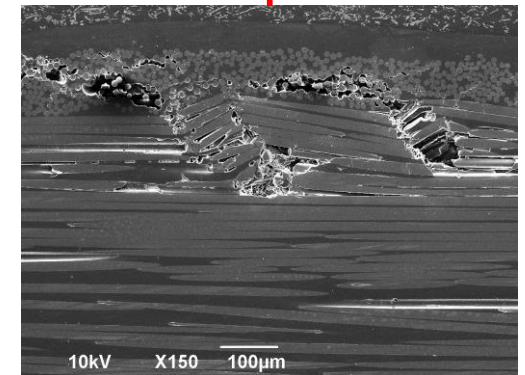
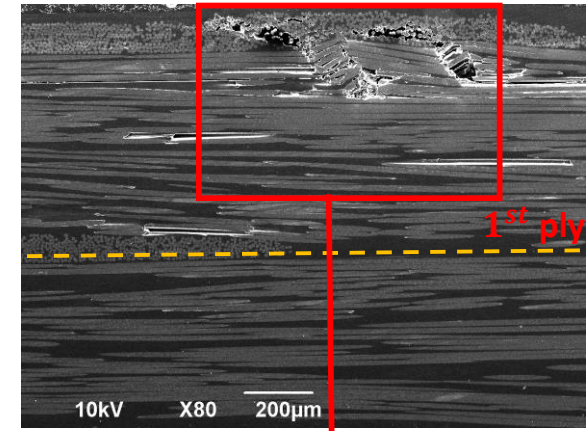
1 Month (97% retention)



2 Months (99% retention)



3 Months (96% retention)



Conclusions

Effect of hydrothermal aging on a glass/vinylester laminate were studied. The following observations and conclusion were drawn based on the results and analysis.

- Interlaminar shear strength appeared to decrease as the immersion time increased.
- A negligible change in flexural strength was observed.

Further analysis is currently underway to investigate these observations.

Acknowledgements



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(www.fibreship.eu) under grant agreement 723360

Thank you for your attention

www.fibreship.eu

http://cordis.europa.eu/project/rcn/210787_en.html

